(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 January 2002 (03.01.2002)

PCT

(10) International Publication Number
WO 02/00512 A1

(51) International Patent Classification[7]: B65D 17/50

(21) International Application Number: PCT/CA01/00954

(22) International Filing Date: 26 June 2001 (26.06.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/603,004 26 June 2000 (26.06.2000) US

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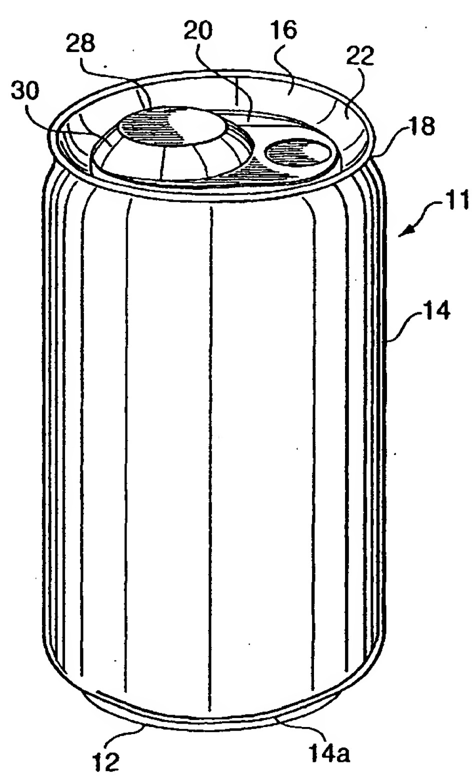
(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European

[Continued on next page]

(54) Title: CAN WITH PEELABLY BONDED CLOSURE



(57) Abstract: A metal can (10) for holding a carbonated beverage or the like, having a rigid metal lid (16) formed with an eccentrically disposed, upwardly projecting frustoconical annular flange (30) defining an aperture (24) of average diameter between about 16 mm and about 25 mm, and a flexible metal foil closure (28) extending over the aperture (24) and peelably bonded by a heat seal to the sloping outer surface of the flange (30).

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patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

CAN WITH PEELABLY BONDED CLOSURE

Technical Field

This invention relates to cans, and more particularly to metal cans having an apertured lid with a heat-sealed, peelable closure for the aperture. In an important specific aspect it is directed to heat-sealed-closure type cans for holding carbonated beverages or like contents that exert a positive internal pressure on the closure, and also to lids for such cans, carbonated beverage-containing packages including such cans, and methods of producing such cans containing carbonated beverages.

Background Art

Heat sealable containers are widely used for a variety of high quality food products. Non-retorted products packaged with heat sealable foil lidding include many types of jams, preserves, yogurt and dairy products, peanuts and snack foods. A wide variety of retortable fish and meat products (including many varieties of pet food) are also packaged using heat sealed foil lidding. In some instances, the entire lid of a can or like container may be removably bonded by heat sealing to a flange formed at an open upper end of the container body, so as to enable the lid to be completely removed, for access to the contents of the container. Other containers, exemplified by cans of tomato or like quiescent fruit juices, have a lid permanently secured to the container body and formed with an aperture (for pouring out the contents) covered by a heat sealed closure or, more commonly, by a closure bonded with a pressure sensitive adhesive. Such a closure is commonly a thin, flexible element, e.g. an aluminum foil-polymer laminate, peripherally bonded by heat sealing to a flange defining the aperture, and has a tab that enables the closure to be peeled manually

from the flange; the flange may be a flat portion of the can lid surrounding the aperture and coplanar with the aperture edge.

For easy opening, typical peel forces (at 90° to the flange) for a heat sealed closure are in a range between about 10 and about 20 Newtons (preferably about 12 Newtons). The retort process involves pressure differentials (from inside to outside) of up to 207 kPa (30 psi), although for many applications, a counter pressure system is used to prevent the lid or closure from bursting off the container. This is necessary because of the reduction in bond strength which generally occurs at the elevated retort temperatures. Moreover, in the case of containers with a lid or closure heat sealed to a flange which is coplanar with the container aperture, internal pressure will cause the lid or closure to bulge over the aperture and, in turn, this bulging exerts a peel force on the heat seal.

Carbonated soft drinks require a container capable of withstanding internal pressures of 620 kPa or higher. Such pressures, or even substantially lesser positive internal pressures, would exert on a conventional heat sealable closure a peeling force more than sufficient to cause burst failure. Increasing the strength of the heat seal bond sufficiently to withstand such forces would make manual peeling of the closure difficult or virtually impossible for many consumers. Consequently, heat sealable closures have not had wide commercial use with canned carbonated beverages. In present-day commercially available carbonated soft drink cans, having a so-called drawn-and-ironed aluminum alloy can body and an aluminum alloy can lid peripherally secured to the open upper end of the body, the can end is commonly formed with a scored area and provided with a

riveted tab system which, when lifted, creates a lever action and exerts a downward force that generates a fracture along a scored line thereby creating an aperture. The region of the lid that lies within the scored area is simultaneously bent down into the top of the container.

Alternative structures have heretofore been proposed or produced with the objective of enabling use of heat sealable closures with containers for carbonated beverages or other substances that create elevated internal pressure. For instance, it has been proposed to provide a spherically domed (rather than planar) lid having an aperture covered by a similarly spherically curved closure member bonded thereto, or to provide a container in which the entire lid is heat-sealed to an angled (rather than planar) flange around the container periphery. In a further alternative, a can lid has been provided with plural small holes (rather than a single aperture) covered by a single foil laminate seal with a pull tab. These alternatives, however, have various limitations or drawbacks.

U.S. Patent No. 3,889,844 describes a can closure in which a can end is shaped to impart a frustoconical area around a pour hole sealed with an adhesive tape tab so that the forces acting on the tape (exerted by can contents under pressure, such as carbonated beverages) tend to place the adhesive in shear instead of in peel. The size of the pour hole described in this patent provides a pour rate which is low as compared to present-day conventional carbonated beverage cans with scored can ends, and the attainment of long shelf life at pressures as high as 620 kPa is not shown.

Disclosure of the Invention

The present invention, in a first aspect, broadly contemplates the provision of a can comprising a metal can body having an open upper end; a substantially rigid metal can lid peripherally secured to and closing the can body end, the lid having an upper surface; a frustoconical annular flange formed in a portion of the lid and projecting upwardly from the lid upper surface, the flange having an upwardly sloping outer surface and an annular inner edge lying substantially in a plane and defining an aperture with an average diameter between about 16 mm and about 25 mm (0.625 - 1 inch), the flange outer surface being oriented at an angle of slope between about 12.5° and about 30° to the plane; and a flexible closure member of a material comprising a metal foil, extending entirely over the aperture and peelably bonded by a heat seal to the flange outer surface entirely around the aperture.

In currently preferred embodiments of the invention, the lid has a substantially flat upper surface. It is also strongly currently preferred that the aperture be circular, because in noncircular apertures there are locations around the perimeter where the tendency of the closure member to peel (burst) is enhanced. The "average diameter" in the case of a circular aperture is, of course, simply the diameter of the aperture.

It will be understood that directions such as "upper" or "upwardly" are used herein with reference to a can standing upright with the lid at the top. The term "angle of slope" refers to the acute angle formed between the plane of the aperture edge and the line representing the flange outer surface as seen in a vertical plane intersecting the aperture edge at a point

at which the line tangent to the aperture edge in the plane of the aperture edge is perpendicular to the vertical plane.

When the can is filled with a carbonated beverage, the closure member is subjected to a differential pressure (hereinafter sometimes designated Δ_P), i.e. a positive difference between the pressure within the can and ambient pressure outside the can, in some circumstances as high as 620 kPa or even more. This differential pressure exerts, on the closure member and heat seal, a force having a tear/shear component (i.e., tending to tear the closure member and shear the heat seal, such component being hereinafter referred to as the tear/shear force and being sometimes designated γ), and in some cases also a peel component.

In currently preferred embodiments of the invention, the closure member material is deformable, and the average diameter of the aperture, the angle of slope of the flange, and the deformability of the material are mutually selected such that the closure member, when subjected to differential pressures up to at least about 620 kPa (preferably up to at least about 687 kPa) in the can, bulges upwardly with an arc of curvature such that a line tangent to the arc at the inner edge of the flange lies at an angle (to the plane of the flange inner edge) not substantially greater than the angle of slope of the flange outer surface, thereby to eliminate any peel component of the force exerted by the differential pressure on the closure member and heat seal.

Also, in some currently preferred embodiments, the closure member and heat seal have a tear/shear force resistance of at least about 13.4 kg/cm (75 lb./in.), and the average diameter of the aperture and the angle

of slope of the flange are mutually selected such that when the closure member is subjected to differential pressure of up to at least about 620 kPa (preferably up to at least about 687 kPa) within the can, the tear/shear force exerted on the closure member and heat seal does not exceed the aforesaid tear/shear force resistance.

As a further particular feature of the invention, in currently preferred embodiments, the annular inner edge of the flange is formed with a reverse bead curl, which may be substantially tangent to the upwardly sloping outer surface of the flange.

Conveniently and advantageously, in at least many instances, the metal foil of the closure member is aluminum alloy foil, e.g. having a thickness between about 75 µ and about 100 µ (0.003 - 0.004 inch). Also advantageously, the heat seal may be formed as an annulus surrounding the aperture and having a width between about 2 to 3 mm. This width of heat seal is found to be sufficient to withstand tear/shear forces encountered in use, and at the same time it facilitates manual peeling of the closure member to open the aperture. To enable such peeling without difficulty, the 90° peel strength of the heat seal is between about 8 and about 20 N, preferably between about 10 and about 16 N. The closure may be provided with a tab portion having a manually graspable free end.

In contrast to the riveted tab structure of conventional carbonated beverage cans, a heat-sealable closure member may become completely separated from the can upon opening, and may then be separately discarded, creating environmental problems. To avoid this consequence, and further in accordance with the invention, the closure may be provided with an extension

overlying the lid in opposed relation to the aforementioned tab portion, and the heat seal may include both an annulus surrounding the aperture as described above and a further seal portion bonding the extension to the lid such that the peel force required to separate the extension from the lid is greater than that required to separate the closure member from the lid at the annulus, the aperture being easily opened by peeling back the closure member from the flange while the closure member remains secured to the lid by the further seal portion. This promotes retention of the closure member on the lid, as desired for environmental reasons. Moreover, the peeled but retained metal foil closure member can be folded over the aperture to provide a measure of coverage and protection for the contents of a can which has been only partially emptied.

Additionally, a body of fragrance-providing material may be disposed between the closure member and the lid and surrounded by the heat seal such that when the closure member is subjected to a peel force effective to open the aperture, the body of fragrance-providing material becomes exposed. The fragrance thereby released, in proximate relation to the nostrils of a person drinking from the can, enhances the effective flavor sensed by the drinker.

The can body may be a drawn and ironed metal can body for holding a carbonated beverage. The lid may be formed with a peripheral rim engaging the open upper end of the can body and projecting upwardly above the upper surface of the lid, the body being formed with an outwardly concave lower end, and the rim and body lower end being mutually shaped and dimensioned to permit stable vertical stacking of the can with other identically shaped and dimensioned cans. In such a

structure, although the flexible closure member (bulging because of the internal pressure) is domed so as to rise to a height above the annular flange, the height of the rim, the concavity of the body lower end, and the height to which the closure rises above the annular flange are such that there is sufficient clearance between the lid upper surface of the can and the concave bottom of another identical can stacked above it to accommodate the domed closure.

Metal foil as used for the closure (e.g. in a foil-polymer laminate) has the advantage of affording excellent gas barrier properties, so that shelf life and quality are improved with foil-based closures. Aluminum foil, for instance, is an effectively perfect barrier for oxygen (important for beer to prevent development of off-flavors owing to oxidation) and for carbon dioxide (important where carbonation levels need to be maintained).

The aperture defined by the flange preferably extends over a minor fraction of the area of the open end of the can body. Especially for holding contents such as carbonated beverages, in cans wherein the open end of the can body has a center of symmetry (e.g. being circular), the annular flange and the aperture are disposed eccentrically of the can body open end so as to be relatively close to the periphery of the lid, for ease of pouring or drinking. That is to say, the flange is disposed in a portion of the lid eccentric to the geometric axis of the can, i.e., close to a side of the can.

Although the shape of the aperture can take different forms, noncircular apertures are nonpreferred, and, in particular, angular apertures or aperture shapes with very small radii of curvature are not suitable for

the present invention. If, instead of a circular aperture, an elliptical or irregularly shaped aperture is provided, e.g. having an aspect ratio between about 1.1 and 1.5, the flange is not strictly frustoconical; it will be understood that the term "frustoconical" is used broadly herein to define an upwardly convergently sloping flange continuously surrounding an aperture, whether the aperture is circular or not.

In further aspects, the invention embraces a can lid member as described above, mountable on a metal can body having an open upper end so as to be peripherally secured to and to close the can body end; the combination of this lid member with a flexible closure member extending entirely over the aperture and peelably bonded to the flange outer surface around the aperture; a carbonated beverage package comprising a can as described above in combination with a body of a carbonated beverage contained within the can; and a method of producing a can containing a carbonated beverage, comprising filling a drawn and ironed metal can body, having an open upper end, with a carbonated beverage, and closing the open upper end of the can body by peripherally securing thereto a metal can lid member as described above having a flexible closure member extending entirely over the aperture defined by its annular flange and peelably bonded to the flange outer surface around the aperture.

In the can of the invention, the provision of the frustoconical annular flange defining the can aperture, and the securing of the flexible closure member by peelable bonding to the upwardly sloping outer surface of this flange, enable the use of a peelably bonded closure member on an otherwise conventional carbonated beverage can, despite the high differential pressure

(positive internal pressure) acting on the closure through the aperture and the resultant outward bulging or doming of the flexible closure member. This is because the angle of slope of the flange can be made steep enough so that a line tangent to the arc of curvature of the domed closure member at the inner edge of the flange lies at an angle (to the plane of the flange inner edge) which is not substantially greater than, and is preferably less than, the angle of slope of the flange outer surface. In such case, the internal pressure acting on the closure member does not exert any significant component of peeling force that would tend to separate the closure member from the flange by peeling. Instead, the forces acting on the peelably bonded flange area owing to tension in the closure member are predominantly shear in character. Heat seal bonds, for instance, are strong under shear loading, especially at ambient temperature; the inability of conventional heat sealed closures to withstand internal pressure in carbonated beverage cans has been caused by the substantial peeling forces exerted on such closures when the closures bulge, under the elevated pressure within a can of carbonated beverage, at a substantial angle to a planar horizontal flange surrounding an aperture.

For a given internal pressure condition, aperture dimension, and closure member, the minimization or elimination of peeling force exerted on a closure bond by elevated pressure within the can is dependent on the angle of slope of the flange. Stated generally, the greater the angle of slope, the easier it is to provide a bonded closure that will not burst from internal pressure yet can be easily manually peeled by a consumer, having regard to the extent of doming of

practicable flexible foil closure members under the pressures within a carbonated beverage can. With the flat lid surface and upwardly projecting frustoconical flange of the present invention, any desired angle of slope can readily be provided, in contrast to the range of angles permitted by other geometries such as a uniformly spherically domed lid having an aperture therein. Moreover, the arrangement of flange, aperture, and domed closure of the invention, occupying only a portion of the area of the can end, enables the height of the closure to be restricted to an extent compatible with convenient vertical stacking of cans.

Further features and advantages of the invention will be apparent from the detailed disclosure hereinbelow set forth, together with the accompanying drawings.

Brief Description of the Drawings

FIG. 1 is a perspective view of a can embodying the present invention in a particular form;

FIG. 2A is an enlarged and somewhat simplified fragmentary elevational sectional view of a portion of the lid member of the can of FIG. 1, including the aperture-defining flange and closure member;

FIG. 2B is a highly simplified and schematic representation of the same view as FIG. 2A;

FIG. 3 is a view similar to FIG. 2A of a flexible closure member bonded to a conventional planar flange defining an aperture;

FIG. 4 is a fragmentary view similar to FIG. 3 of a portion of the flange and closure member of the embodiment of the invention shown in FIGS. 2A and 2B;

FIG. 5 is a simplified and somewhat schematic top plan view of the can of FIG. 1;

FIG. 6 is an exploded diagrammatic elevational sectional view of the can lid and closure member of FIG. 5;

FIG. 7 is a plan view of the closure member of FIG. 5;

FIG. 8 is a side elevational view, partly broken away, of two cans having the structure shown in FIG. 1, illustrating the ability of the cans to be stacked vertically;

FIG. 9 is a view similar to FIG. 2B illustrating a condition of excessive bulging of the closure member;

FIG. 10 is a graph representing the relationship between sealing temperature and peel strength in Example 2 described below;

FIG. 11 is a graph representing the relationship between heat seal temperature and burst pressure in the same example;

FIG. 12 is an enlarged fragmentary sectional elevational view of a portion of a lid member embodying the present invention;

FIG. 13 is a schematic fragmentary sectional elevational view of a lid member embodying the invention;

FIG. 14 is a graph showing bulge height of an exemplary closure member as a function of pressure within the can (i.e., differential pressure Δ_P);

FIG. 15 is a schematic plan view of a can lid embodying the invention and having a "stay-on" closure member;

FIG. 16 is a graph showing 90° peel force as a function of displacement of the closure member of FIG. 15;

FIGS. 17A and 17B are highly schematic fragmentary elevational sectional views in illustration of a further

embodiment of the invention including a fragrance reservoir;

FIG. 18 is a sectional elevational view of one form of can lid embodying the invention and including a fragrance reservoir; and

FIGS. 19 and 20 are views similar to FIG. 15 of two can lids embodying the invention and including both a stay-on closure member and a fragrance reservoir.

Best Modes for Carrying Out the Invention

The container of the invention will be described, with reference to the drawings, as embodied in a metal can 10 for holding a carbonated beverage such as soda or beer. The can 10 includes a one-piece can body 11 constituting the bottom 12 and continuous, upright, axially elongated, generally cylindrical side wall 14 of the can, and a lid 16 which, after the can has been filled with the beverage, is peripherally secured to the open top end of the can body to provide a complete, liquid-tight container.

In this embodiment, the body 11 may be an entirely conventional drawn-and-ironed aluminum alloy can body, identical in structure, alloy composition, method of fabrication, configuration, gauge, dimensions and surface coatings to can bodies currently commercially used for carbonated and other beverages (alternatively, for example, the body may be a steel can body, such as are in common use in Europe). In particular, and in common with known can bodies, the bottom 12 of the body 11 is externally concave and the open top end of the body has a circular edge 18 lying in a plane perpendicular to the vertical geometric axis of the side wall 14. The terms "aluminum" and "aluminum alloy" are

used interchangeably herein to designate aluminum metal and aluminum-based alloys.

Except as hereinafter described, the lid 16 may also be a generally conventional aluminum alloy lid member of the type currently commercially used for beverage cans having drawn and ironed one-piece can bodies such as the body 11. Thus, the alloy of which it is constituted, the steps and procedures employed in its fabrication (with the exceptions noted below), and its general overall configuration, dimensions, gauge and surface coatings as well as the manner in which it is secured to the top edge 18 of the can body 11, may all be the same as in the case of present day can lids well-known in the art.

It should be noted, however, that since the can lid of the present invention is not subjected to the rivet-forming and scoring operations that must be performed on currently conventional can lids, the invention may permit the use of nonconventional can lid alloys and materials. For example, coated steel can lids, which are normally too difficult to open by the conventional scoring mechanisms, could be used in the practice of the invention. Similarly, AA 3104 alloy, commonly used for can bodies (but not, heretofore, for can lids), when used at an appropriate gauge, may have sufficient strength for the lid structure of the present invention; it could offer the advantages of lower cost as compared to the AA 5128 alloy currently used for can lids and would also afford benefits for recycling, in that the can lid and body would be made of the same alloy.

In particular, the lid 16 in this illustrated embodiment is substantially rigid, and has a substantially flat upper surface 20 with a circular periphery, around which is formed a raised annular rim

22 projecting upwardly above the plane of the flat upper surface 20. When the lid is mounted on the open upper end of a beverage-filled can body, in known manner, the rim 22 engages the upper edge 18 of the can body; the circular flat surface 20 lies substantially in a horizontal plane, perpendicular to the vertical geometric axis of the cylindrical side wall 14, and is centered with respect to the latter axis.

The lower end 14a of the side wall 14 of the can 10 is shaped (tapered) to interfit with the rim 22 of the lid of another identical can 10a, when the can 10 is stacked vertically on top of the can 10a as shown in FIG. 8. A multiplicity of the cans may thus be stably vertically stacked, one on another, as is true of present-day conventional cans of the same general type. The elevation of the lid rim 22 above the flat upper surface 20 of the lid, together with the concavity of the can bottom 14, cooperatively define a central gap or space between the lid of one can and the bottom of the next can above it, in such a stacked arrangement.

Also in common with present-day conventional lid members used with one-piece drawn-and-ironed aluminum alloy beverage can bodies, the lid 16, when secured to the beverage-filled can body, provides therewith a complete sealed enclosure holding the beverage. The lid is thus subjected to elevated internal pressure within the can (i.e., pressure higher than ambient atmospheric pressure) if the beverage is carbonated. However, the formed aluminum alloy lid is substantially rigid, so that it undergoes at most only a small deflection of its upper surface as a result of this pressure condition, and the upper surface 20 remains substantially flat notwithstanding the internal pressure acting on the lid.

The lid 16 is arranged to provide an aperture

through which the beverage contained in the can may be poured or removed by drinking directly from the can, either with a straw inserted through the aperture or by juxtaposition of the consumer's mouth to the aperture. Heretofore, in cans for holding carbonated beverages or other such contents at elevated pressure, the aperture-providing feature has conventionally included a scored portion of the metal of the lid member and a riveted pull tab system for parting the lid metal along the score line to open the aperture.

The present invention, in contrast, provides a pre-formed open aperture 24 in the lid, and a peelable, flexible closure member 28 covering the aperture. In order to achieve adequate burst resistance without requiring excessive force to peel the closure member, a shallow frustoconical annular flange 30 is formed in the lid within the area of the flat upper surface 20, to surround and define the aperture 24 and to provide a seat for the closure member.

More particularly, the flange 30 projects upwardly from the upper surface 20 of the lid, and has an upwardly sloping outer flange surface 32 and an annular inner edge 34 defining the aperture 24, which is illustrated as being of circular configuration but is not limited to a circular shape. The inner edge 34, as shown in FIGS. 2A and 2B, is preferably formed as a bead 36 with a reverse curl, which is tangent to a horizontal plane represented by line P (FIGS. 2A and 2B) and to the line of slope of the outer flange surface 32 so that, once the closure member 28 is heat-sealed to the flange surface, the cut metal (typically an aluminum alloy) at edge 34 cannot come into contact with the contained beverage. This is advantageous because the cut metal at the edge (unlike the major surfaces of the lid) has no

protective coating, and would be attacked by acidic or salt-containing beverages if it were exposed thereto. The reverse curl of bead 36 also prevents a drinker's lips from touching and being injured by the cut metal at edge 34, and avoids any possibility of damage to the closure member by contact with the cut metal. However, the invention may also be embodied in a can wherein the aperture has a standard (not reverse) bead curl, which also affords such benefits as safety for the consumer, it being noted that where the cut edge of the metal is not kept from contact with the contained liquid by a reverse curl, it may be protected by application to the cut edge of a lacquer.

The flexible closure member 28 is constituted of a sheet material comprising metal foil, e.g. aluminum foil; in the described embodiment of the invention, the closure member is fabricated of an aluminum foil-polymer laminate sheet. Stated more broadly, materials that may be used for the closure member include, without limitation, lacquer coated foil (where the lacquer is a suitable heat seal formulation); extrusion coated foil (where the polymer is applied by a standard or other extrusion coating process); the aforementioned foil-polymer laminate, wherein the foil is laminated to a polymer film using an adhesive tie layer; and foil-paper-lacquer combinations such as have heretofore been used for some low-cost packaging applications.

The closure member extends entirely over the aperture 24 and is secured to the flange outer surface 32 by a heat seal extending at least throughout the area of an annulus entirely surrounding the aperture. Since the reverse curl bead 36 does not project beyond the slope of the flange outer surface, the closure member smoothly overlies this bead as well as the flange outer

surface, affording good sealing contact between the closure member and the flange.

The closure member, in the described embodiment of the invention, is bonded by heat sealing to the flange 30, covering and closing the aperture 24, before the lid member 16 is secured to a can body 11 filled with a carbonated beverage. Once the lid has been mounted on the body to complete the enclosure of the beverage, elevated pressure generated by the beverage acts on the inner surface portion of closure member 28 which is exposed through the aperture to the interior of the can, causing the flexible closure member to bulge outwardly. Further in accordance with the invention, however, the angle θ (FIG. 2A) of slope of the flange outer surface relative to the plane of the annular edge 34 (i.e., plane P) is selected to be such that a line tangent to the arc of curvature of the bulged closure member at the inner edge of the flange lies at an angle to plane P not substantially greater than the angle θ of slope of the flange outer surface. As indicated in FIG. 2B, since the upper surface 20 of the lid member 16 is flat and horizontal (and thus parallel to plane P), θ may alternatively be defined as the angle of slope of the flange outer surface to the flat lid surface 20.

Preferably the angle θ is between about 12.5° and about 30° to the plane P, and more preferably at least 15°. In currently particularly preferred embodiments, the angle θ of slope is between about 18° and about 25° to the plane P.

In FIGS. 2A and 2B, A is the diameter of the aperture 24 in plane P, R is the radius of curvature of the bulged or domed closure member 28, and h is the maximum vertical height of the domed closure member above the aperture plane P. In these figures, the foil

closure is shown domed to the point at which the flange is tangential to the arc of the domed foil closure member 28, i.e., at which the line of slope of the flange surface 32 as seen in a vertical plane is tangent to the arc of curvature of the closure 28 (as seen in the same vertical plane) at the edge of aperture 24.

For the closure configuration illustrated in FIGS. 2A and 2B, the forces acting on the heat sealed flange area due to the tension in the foil, are predominantly shear in character, with no significant peel force component. In this case, the burst resistance will depend on the shear strength of the heat seal joint or the bulge strength of the foil or foil laminate itself. This ensures that the burst resistance of the lid is enhanced significantly compared to that of a standard heat sealed container.

Heat seal bonds are strong under shear loading, especially at ambient temperature, and an annular heat seal about 2 mm - 3 mm wide is sufficient to resist the anticipated shear forces which result from the internal pressure. If the foil is domed to a lesser extent than shown in FIGS. 2A and 2B, relative to the flange slope angle θ, the foil laminate will tend to hold down the heat seal bond with a corresponding additional enhancement of the burst resistance. If, however, the foil were domed to a greater extent than is shown in FIGS. 2A and 2B, relative to the flange slope angle, a peel force component would arise at the inner edge of the aperture, with an increased likelihood of burst failure.

The frustoconical aperture-defining flange enables provision of a flange slope angle θ sufficient to accommodate the extent of doming or bulging of the closure member to be used therewith, under the elevated

internal pressures for which the can is designed, and thereby enables the burst resistance to be enhanced without increasing the peel force requirement.

As will therefore be clear, the flange slope angle and the form of the foil closure strongly influence the burst resistance. In addition to the flange slope angle and extent of doming of the closure, not only the resistance of the heat seal bond to shear forces but also the strength of the foil of the closure member are selected to withstand the forces acting thereon. If the flange slope angle, in accordance with the invention, is such as to substantially avoid any substantial peel force component of forces acting on the heat sealed area owing to tension in the foil from the internal pressure acting on the closure member, and if the heat seal bond and the shear resistance of the bond are adequate, burst failure could occur by failure of the foil itself. The shear force required to break the heat seal bond can be adjusted either by increasing the width of the heat sealed region, or by selecting laminates or coating formulations which achieve a higher shear strength. Both of these expedients, however, would increase the peel force required to open the container.

The effect of heat sealing the closure member 28 to a sloping flange surface rather than a horizontal flange surface, will be apparent from a comparison of FIGS. 3 and 4. FIG. 3 represents an aperture 40 in a conventional lid member 41 wherein the flange 42 around the aperture is simply a flat horizontal portion of the lid upper surface, coplanar with the aperture edge 43. A flexible closure member 44 covering the aperture 40 and bonded by heat sealing to the coplanar flange 42 will bulge, in the same manner as the closure member 28 in FIG. 2A, if the lid member 41 is mounted on a can

body filled with a carbonated beverage or other pressure-generating contents. Assuming that equal elevated pressures exist within the cans of FIGS. 2A and 3, that the diameters of apertures 24 and 40 are equal, and that the same flexible sheet material is used for the closure members 28 and 44, the extent of bulging of the closure members (defined by h and R) should be essentially identical in both cans. In the case of the planar flange of FIG. 3, the consequent tension force F_T acting on the heat-seal-bonded portion of the closure member 44 at the edge of the aperture 40 will have a substantial peeling force component F_P acting at 90° to the plane of the flange surface. In the case of the sloping flange of the invention, however, as shown in FIG. 4, owing to the above-described relation of angle θ to the angle of the tangent to the arc of curvature of the domed closure member 28 at the aperture edge 34 (in which, in FIG. 4, the reverse curl is omitted for simplicity of illustration), the same tension force F_T (which acts in the direction of the aforementioned tangent at the edge of the aperture) has no significant peeling force component F_P acting in direction D at 90° to the plane of the (sloping) flange surface 32.

Under the pressures that may obtain within a can of carbonated beverage, the peeling force component F_P acting on a flange that is coplanar with the aperture edge can be sufficient to cause the closure member to progressively separate from the flange by peeling until it bursts open, at least if the strength of the heat seal bond is within conventional limits as desired for ease of peeling by a user. The sloping of the flange prevents this from happening, and thereby increases the burst resistance of the heat-sealed closure member sufficiently to enable its safe use on a carbonated

beverage can without having to increase the heat seal bond strength to a point which would make the closure member difficult to remove by a user.

It will be understood that the extent of bulging of the closure member under the influence of pressure within the can, and thus the angle of the tangent (relative to plane P) to the bulged or domed closure member at the aperture edge, is dependent on the pressure within the can and the elastic deformability of the closure member. Desirably, the slope angle θ of the flange surface 32 should be chosen to be sufficiently large so as to be compatible with the bulging characteristic of the chosen closure member material. The provision of the flange, which serves as a seat for the heat sealing of the closure member, as a frustoconical projection from a (preferably substantially flat) upper surface of a substantially rigid lid, facilitates this provision of a relatively large slope angle. At the same time, by making the aperture area a minor fraction of the total area of the can open end, the height h of the domed closure may readily be kept sufficiently small to be accommodated between the lid of one can and the concave bottom of another when the cans are stacked vertically as shown in FIG. 8.

Further, it will be understood that the benefits of the invention may be realized even if the flexible closure member bulges slightly beyond the ideal limit of tangency to the slope of the flange. In such a case, the peel component of force will start to grow, but may still be insufficient to cause failure of the bond.

FIGS. 5 - 7 illustrate further the configuration and arrangement of the flange, aperture and closure member at the top of the can in the embodiment of

FIG. 1. With a circular can lid member 16 having a diameter of 48 mm, mountable on a can body having a correspondingly dimensioned circular open upper end, a circular aperture 24 having a diameter of 20 mm is defined by a frustoconical annular flange 30 having a maximum diameter (in the plane of lid surface 20) of 30 mm. As best seen in FIG. 7, the foil-polymer laminate closure member 28 has a circular central portion 32 mm in diameter (large enough to completely overlie the sloping outer surface of the flange), with a short projection 28a on one side for overlying part of the flat upper surface of the lid and an integral tab portion 28b on the opposite side which, outwardly of the flange 30, is not heat sealed but is free to be bent and pulled. The exploded diagrammatic elevational view of FIG. 6 indicates the relative positions of the can lid 16 and the closure member 28, as well as the folding of the tab. The closure member is subjected to a preliminary forming step to impart a frustoconical shape (also indicated in FIG. 6) to its circular central portion for proper seating on and sealing to the flange 30.

The aperture 24 is shown in FIG. 5 as being disposed eccentrically of the geometric center (center of symmetry) of the can lid 16, i.e., relatively close to the edge of the lid, so that a user can easily bring the aperture to his or her mouth for drinking the contained beverage directly from the can. However, depending on use and contents, different positions for the aperture may be employed. Also, if desired, aperture configurations other than the circular shape shown may be provided.

The manufacture of the can of the invention, including particularly the lid and closure, may (as

stated) be in many respects generally conventional. However, certain modifications of conventional practice and equipment, now to be described, are employed to achieve the novel flange shape and the heat sealing of the closure member thereto.

Illustratively, but without in any way limiting the invention thereto, the foil laminate closure stock may be a suitable aluminum foil (e.g. made of the aluminum alloy identified by Aluminum Association registration No. AA3104, with a foil gauge of 75 μ - 100 μ laminated on one side with a suitable heat sealable polymer film (e.g., polyethylene or polypropylene, 25 μ - 50 μ thick). The other (outwardly exposed) side should have a suitable protective lacquer coating. It may be desirable to print onto the foil using rotogravure, flexographic or another known printing method. It may also be desirable to emboss the laminate to provide an attractive surface texture which enhances the appearance of the closure and assists in opening by making the closure easier to grip.

In order to seal to the aperture, the closure members 28 with their described integral pull tabs are formed and stamped out from the foil laminate stock using a suitable press (standard presses can be used with tooling specifically designed for these closure members), and are shaped (by a drawing process) so that they will fit over the raised aperture of the lid.

A heat sealing machine with tooling designed to conform to the frustoconical flange shape is used to heat seal the closures to the can lid. That is to say, the tooling is angled to match the flange (and the formed closure). The exact heat sealing conditions are dependent on the polymer and heat seal coating formulation used. Since the inside coating of the can

lid member 16 should not be significantly softened or melted during the heat sealing operation, the bottom heat seal tool should be held at a relatively low temperature (<50°C). The upper tool temperature is set to ensure that the heat seal bond is achieved in an acceptably short time. Typical commercial heat sealing machines have dwell times of 0.3 sec. The dwell time, pressure and temperatures may be optimized for the particular heat seal application. Heat sealing the closure to the lid involves use of a customized heat sealing line (such as those built by Hans Rychiger AG, Steffisburg, Switzerland), with appropriately constructed heat seal tooling provided to bond the closure to the angled aperture.

The forming of the can lid member 16 itself with the frustoconical flange 30 and aperture 24 as described is relatively straightforward, using modified can end forming tooling, with provision for forming the reverse curl bead 36. The can lids of the invention do not require the formation of a rivet or tab.

The lids, complete with heat sealed closures, are substantially compatible with existing can filling lines and will be a direct replacement for the currently commercially used lids for cans for carbonated beverages and the like. Modifications may be made in the lid handling equipment to minimize or eliminate the possibility of damaging the raised aperture and closure.

Alternatively, the can lid may initially be provided with the aperture 28 and reverse curl bead 36 around the edge thereof, and the closure member 28 may be heat sealed to the upper surface of the lid in covering relation to the aperture, before the upwardly sloping frustoconical configuration is imparted to the flange portion of the lid immediately surrounding the

aperture. Forming of the frustoconical flange 30 then proceeds, with concomitant deformation of the already heat sealed foil closure member, followed by mounting of the lid on a can body already filled with carbonated beverage.

As initially applied to the can lid, the portion of the closure member 28 extending across the aperture may be substantially planar as indicated at 28c in FIG. 12, which shows a frustoconical flange 30 having an angle of slope θ of 23°. When the lid is mounted on a can body filled with a carbonated beverage, so as to completely enclose the beverage, the resultant pressure within the can creates a positive differential pressure Δ_P causing the deformable closure member to bulge upwardly. FIG. 13 illustrates the location of the heat seal annulus 46 on the sloping outer surface of the frustoconical flange 30.

A particular feature of the present invention is the dimension of the aperture 24. There is a consumer preference for cans with good pouring characteristics (good pour rate with a smooth, streamlined flow). Cans with large opening ends (LOEs) have been introduced in recent years and have been successful, especially for beverages with lower carbonation levels (e.g. lemonade and iced tea), although in the case of highly carbonated beverages, problems with score line failure and burst resistance have been encountered. A conventional shape of apertures for beverage cans is approximately oval with an aspect ratio between about 1.1 and about 1.5. A standard aperture is 17.8 mm in diameter and an LOE is 25.4 mm x 17.8 mm; thus, the current aperture size for a carbonated beverage container, expressed as average diameter, is from about 17.8 mm to about 22.2 mm.

Some can designs have also provided a separate vent hole in the lid to improve pouring and drinking characteristics, but the inclusion of the vent hole adds to manufacturing cost and may complicate the opening process for the consumer.

The aperture size and shape are important in determining pouring and drinking characteristics. In general, larger aperture sizes give better flow rates with a more even flow. The relation between aperture and flow rates is illustrated by the following test data obtained in experimental pouring tests with the can lid oriented downwardly at an angle of 30° to the horizontal:

TABLE 1

Aperture	Pour Rate (g./sec.)
Standard can aperture	56
LOE	70
14.3 mm, flat flange	18
15.9 mm, flat flange	31
19.0 mm, flat flange	50
22.2 mm, flat flange	75
14.3 mm, angled flange	24
15.9 mm, angled flange	35
19.0 mm, angled flange	56
22.2 mm, angled flange	93

In the above table, "angled flange" means an upwardly sloping frustoconical flange as provided in the present invention; "flat flange" means that the portion of the lid surrounding the aperture is substantially coplanar with the aperture edge, as in conventional can lids.

As will be apparent from Table 1, for equivalent hole sizes, the pour rate for "angled flange" apertures is higher by about 10 to 15% at a 30° tilt than that for "flat flange" apertures. The 19.0 mm angled flange aperture has a pouring rate at 30° tilt approximately the same as that of the current standard can aperture. The 14.3 mm aperture (with both flat and angled flanges) has a significantly lower pour rate than that of the current standard can aperture. The 22.2 mm angled flange aperture provides a higher pour rate than the LOE design (which, like the standard can, has a flat flange). For the aperture range of interest, the pour rate is approximately proportional to aperture area.

As hereinafter further explained, the tear/shear forces acting on the closure member and seal tend to increase with aperture size, so that the maximum aperture diameter is limited by the need to provide a can with adequately high burst pressure or burst resistance (i.e., the pressure at which the closure member and seal rupture or fail). Therefore, the range of average aperture diameter in accordance with the present invention is between about 15.9 mm and about 25.4 mm, to afford satisfactory pour rates (without any separate vent hole) and at the same time to achieve high burst resistance without sacrifice of other characteristics such as peelability.

Another important characteristic, for attainment of adequately high burst resistance, is the tear/shear

force imposed on the heat seal and closure member by a given differential pressure. The tear/shear force γ (kg/cm) is determined by the differential pressure Δ_P (kg/cm^2), aperture diameter A (cm) and angle of slope θ of the frustoconical flange 30, in accordance with the relation

$$\gamma = \frac{A \bullet \Delta_P}{4 \sin\theta} \qquad (1)$$

In particular instances, depending (for example) on the degree of carbonation of the contained beverage and the consequent magnitude of differential pressure that the can, closure and seal must be designed to withstand, the design value of tear/shear force resistance for a can in accordance with the invention (i.e., the value that the closure member and heat seal must be able to withstand) may range from less than (or about) 4.5 kg/cm (25 lb./in.) to about (or even somewhat more than) 75 lb./in., a tear/shear resistance of about 13.4 kg/cm being currently preferred in many cases. Typical filling line pressures for carbonated beverages are between about 345 and about 414 kPa, though for some beverages (sports drinks, lemonade, etc.), lower carbonation levels are used. However, in order to take account of extreme conditions (temperature, agitation, etc.) a minimum test burst pressure requirement of 620 kPa is currently specified for many applications, and a burst resistance of 689.5 kPa would be even more desirable.

$\frac{75\ \text{lb}}{\text{in}} \times \frac{1\ \text{kg}}{2.2\ \text{lb}} \times \frac{1}{2.54}$

Table 2 sets forth values calculated using relation (1) above for tear/shear force γ (kg/cm) for various aperture diameters A and flange slope angles θ at a differential pressure Δ_P of 7.03 kg/cm^2 (100 psi).

TABLE 2

γ(kg/cm)

θ°	A(cm)=	1.27	1.59	1.90	2.22	2.54	2.86	3.17
2.5		51.2	64.0	76.8	89.6	102.4	115.2	127.9
5		25.6	32.0	38.4	44.8	51.2	57.6	64.0
7.5		17.1	21.4	25.6	29.9	34.2	38.5	42.8
10		12.9	16.1	19.3	22.5	25.7	28.9	32.1
12.5		10.3	12.9	15.5	18.1	20.6	23.2	25.8
15		8.6	10.8	12.9	15.1	17.3	19.4	21.6
17.5		7.4	9.3	11.1	13.0	14.8	16.7	18.6
20		6.5	8.2	9.8	11.4	13.1	14.7	16.3
22.5		5.8	7.3	8.7	10.2	11.7	13.1	14.6
25		5.3	6.6	7.9	9.3	10.6	11.9	13.2

These are the minimum strength requirements (kg/cm) for the closure member and heat seal to withstand a pressure differential Δ_P of 7.03 kg/cm^2 without rupture or failure (bursting), for each specified combination of aperture diameter A and slope angle θ. As is apparent, for a given differential pressure, the tear/shear force strength requirement decreases with increasing flange angle and increases with increasing aperture diameter.

By way of illustration, an aperture diameter of 2.2 cm and a flange angle of about 22.5° would require a closure foil with a breaking strength in excess of 10.2 kg/cm and an equivalent minimum heat seal shear strength, for burst resistance of 7.03 kg/cm^2.

Typical aluminum lidding foils of 75 µ thickness can withstand a tear force in excess of13.4 kg/cm. Practicable heat seals capable of withstanding a shear force of 75 lb./in. can also readily be provided, in configurations suitable for the heat seal 46. Therefore, combinations of A and θ in Table 2 for which the calculated value of γ is13.4 kg/cm or less enable

satisfactory and practicable attainment of a burst resistance of 7.03 kg/cm^2 in the can of the present invention.

As already stated, to avoid a peel component in the force exerted on the closure member and heat seal by the differential pressure Δ_P, the bulge height h of the closure member above the plane P of the aperture 24 should not exceed a value h_{max} at which the slope of the flange 30 is tangent to the arc of the bulging closure at the edge of the aperture. This upper limiting value h_{max} (in mm) is, again, determined by the angle of slope θ of the flange and the aperture diameter A (in mm) of the aperture 24; in the case of a circular aperture, such limiting value can be calculated using the relation

$$h_{max} = \frac{A}{2}\left(\frac{1}{\sin\theta} - \frac{1}{\tan\theta}\right) \qquad (2)$$

It will be seen that the maximum permitted bulge height, to achieve the described freedom from any peel component, increases with aperture diameter and also increases with flange angle.

The actual bulge height in a closure member 28 produced by a given differential pressure Δ_P is dependent on the properties of the closure foil related to deformation, i.e., the deformability of the foil, as well as on the aperture diameter. FIG. 14 illustrates the relationship of bulge height h (here given in mm) to pressure Δ_P for a 22.2 mm aperture diameter and an exemplary aluminum foil 100 µ thick.

Examples of the maximum permitted bulge height (mm) as defined above, calculated for a circular aperture using relation (2), for various combinations of A (in mm) and θ, are set forth in Table 3:

TABLE 3

h_{max} (mm)

A(mm)	θ° =	17.5	20	22.5	25	27.5	30
15.9		1.2	1.4	1.6	1.7	1.9	2.1
19		1.5	1.7	1.9	2.1	2.3	2.5
22.2		1.7	1.9	2.2	2.5	2.7	3.0
25.4		1.9	2.2	2.5	2.8	3.1	3.4

For an aperture diameter of 22.2 mm with a flange slope angle of 22.5°, the maximum bulge height should be 2.2 mm to avoid peel force components.

If the bulge height exceeds the critical value, FIG. 14 can be used to determine the angle of the tangent to the arc of the bulging closure foil at the edge of the aperture. If the stress within the foil can be determined, the peel component of the stress can be estimated. Provided that this component is less than the measured peel stress for the closure material, failure by peeling will not occur. However, it is preferred that the lid parameters be chosen to ensure that the bulge height does not exceed the above-defined limiting value at least for differential pressures up to 620 kPa, more preferably for differential pressures up to 689 kPa.

Metal foils have comparatively good creep resistance over the range of temperatures that may be experienced in service, and therefore afford an important advantage over polymeric closure member materials with respect to creep susceptibility and consequent short shelf life. Since creep is dependent on applied stress, increasing the thickness of the closure material can reduce or eliminate creep. For aluminum foil closure members, a thickness between about 75 - 100 μ is sufficient to virtually eliminate creep.

The performance of the bond between the closure

membrane and the lid flange is dependent on the properties of the adhesive layer and on the design of the joint. The flange angle is designed to ensure that the forces between the closure membrane and the flange are predominantly shear in character under the fully pressurized conditions of use. However, the shear stress in the joint can be affected by the width of the heat seal; i.e., increasing the width of the bond spreads the load and thereby reduces the stress intensity.

It is desirable for the width of the heat seal to be less than about 3 mm and preferably about 2 mm. If the width is increased above about 3 mm, the peel force required to open the container will be increased. Furthermore, an increased heat seal (and flange) width would mean that the drinking aperture has to be located further from the container edge, detracting from the convenience of the consumer by making the container less comfortable and more inconvenient to drink from.

Experimentally, it is found that a 2 mm wide heat seal annulus for the foil closure performs well in the can of the invention (see Example 4 below). Fully pressurized cans have been stored at ambient temperature (20°C) for several weeks, with no detectable sign of creep in either the foil or in the adhesive bond joint.

In containers for beverages and the like with manually peelable closures, the peel force required to open the container should preferably fall within the range between about 8N and 20N, and still more preferably within the range between about 10N and 16N as measured by a 90° peel test. The peel force required is dependent on the peel strength of the bond and on the effective width of the seal during the peeling procedure. In the case of an angled flange, there will

also be a geometrical factor, which will affect the final peel force required.

In the case of heat seal bonding, the peel strength is influenced by the particular lacquer formulations on the two mating surfaces, and on the heat sealing conditions which are used. For example, in one preferred embodiment, the outer can end panel surface has a thin vinyl lacquer coating (Valspar Unicoat®, up to about 2 μ thick) and the aluminum foil closure material has a vinyl based heat seal lacquer (Alcan Rorschach TH388®, between about 5 and 8 μ thick).

For this combination of coatings, the peel strength falls within an acceptable range for peelability. At the same time, provided the closure foil has sufficient strength, the heat seal bond can meet the requirements for shear strength.

Variations in peel strength can be obtained by changes to the heat sealing temperature, the heat sealing pressure and/or the dwell time for sealing.

In addition to the aforementioned vinyl based lacquer systems, various other combinations of can end lacquer and heat seal coatings have been found to be suitable for the present invention. These are exemplified, without limitation, as follows:

Can lid coating (exposed side)	Foil Closure coating
Epoxy coating (solvent based lacquer)	
Polypropylene (extrusion coated)	Polypropylene based heat sealed lacquer
Laminated polypropylene	Polypropylene formulation:extrusion coated
Polyester coated (e.g. extrusion coated)	Polyester compatible heat seal coating

It should be recognized that the combination of specific coating formulations on the can lid (exposed

aperture 124 surrounded by an angled flange to which a foil closure member 128 is bonded by an annular portion 146a of a heat seal. On the side of the aperture adjacent the lid edge, the closure member has an integrally formed pull tab 128b (folded back over the aperture, with its unfolded position indicated at 128b'). The closure member also has an integral "stay-on" extension 128a positioned in opposed relation to tab 128b (with respect to the aperture) and overlying the flat upper surface of the lid. Extension 128a is bonded to the lid by a further heat seal portion 146c, which is so dimensioned as to require a substantially greater peeling force (for separating extension 128a from the lid) than that required by annular heat seal portion 146a (for separating the closure member from the angled flange around the aperture).

In other words, the closure member 128 of FIG. 15 includes a "stay-on" tab area or extension 128a which is sealed to the lid panel 116 by portion 146c of the heat seal that has a size and shape which requires a substantially higher peel force (greater resistance to peeling) than the annular seal portion 146a surrounding the aperture 124, thereby discouraging the consumer from completely removing the closure foil. As a result of this design, when the consumer peels open the closure, the peel will initially be within the targeted range for each opening, e.g. about 10-20N. Then as the aperture is completely opened, the peel force will fall to a very low value so that the consumer will sense that the opening is completed. If the consumer continues to pull the closure, the required peel force will rise rapidly to a value which exceeds the normally accepted easy peel range, i.e. about 25N. An example of the peel

characteristics of a closure of this invention is given in FIG. 16.

This variation in peel force requirement can be achieved most readily by careful design of the seal region, in particular by appropriately selecting the dimensions of the heat seal portions 146a and 146c. In the case of a heat sealed closure, this is easily achieved by the design of the heat seal tooling. With a pressure sensitive adhesive, it would be more difficult and would require the adhesive to be printed onto the closure film in the desired pattern.

FIG. 16 is a graph showing a typical variation of peel force (90° peel test) as the closure is peeled open. As the peel is initiated, the force rapidly increases as the foil peels away from the region of the flange on the pull tab side 128b. As the foil is peeled from the remainder of the flange and opens the aperture, the peel force remains fairly constant, rising to a second maximum at the end of the aperture. At this point, the foil is not sealed to the lid, and the peel force falls quickly to a low value. At the start of the "stay-on" extension region, the peel force rises to a high value to discourage the consumer from completely removing the closure foil.

Further control of the peel force can be obtained by varying the heat sealing conditions in the different regions of the closure. For example, if the temperature of the heat seal in the stay-on extension region were increased, a high peel strength would result. It is also possible to use a different heat seal lacquer, with a higher inherent peel strength, in the "stay-on" extension region. Yet another method of increasing the peel force requirement in the "stay-on" tab region is by the use of one or more ridges or other profiled features

(not shown). Such features would serve to increase the effective area of the seal and to provide a degree of mechanical keying for the closure.

As discussed above with reference to FIG. 15, the peel force varies as the closure is peeled back. The detailed variation of the peel force required can be adjusted and controlled by the various methods described. The variation shown in FIG. 16 corresponds to a desirable behavior for the consumer, in that the uniform peel force after an initial higher start force provides ease of opening for the container; the subsequent drop in peel force gives the consumer an indication (by feel) that the aperture is completely opened; and, finally, the rapid rise of the force due to the "stay-on" extension signals the consumer that the closure is intended to stay on and be folded back for drinking.

With an aluminum foil closure material, employing a "stay-on" arrangement as described, the closure can be easily folded down so that it does not significantly interfere with the drinking experience of the consumer. Furthermore, since the foil has good dead-fold characteristics (i.e. it does not exhibit any noticeable spring back), the closure can be folded back over the aperture if desired. Although this does not reseal the can, it would prevent the undesired ingress of dirt or insects into the beverage between drinks, and may also reduce the spillage if a can is accidentally tipped.

Yet another advantageous feature of the invention, in particular embodiments as illustrated in FIGS. 17-20, is the incorporation of a source of a fragrance or aroma in the can lid, so that peeling of the closure member to open the can also acts to expose a small quantity of an oil or wax based aroma concentrate, located on the lid

in a position which is in close proximity to the nostrils of a person drinking from the can aperture. The aroma is selected to enhance or complement the taste of the beverage.

It is well known that the senses of smell and taste are closely related, and in particular that the sense of smell can significantly enhance the taste experience. Preservation or enhancement of a smell associated with a particular beverage, thereby improving the aroma of the product, may serve to increase the overall enjoyment of the product. Fragrances which may be thus provided may include (by way of nonlimiting illustration) lemon, orange, lime, mint, etc.

The aroma-enhancing feature may, for example, advantageously be incorporated in a can lid 116 having a "stay-on" foil closure member 128 as described above with reference to FIGS. 15-16. A small part of the lid area, initially covered by the foil closure member (FIG. 17A) but exposed upon peeling of the closure member (FIG. 17B), is modified so as to receive a small quantity 156 of an oil- or wax-based fragrance. This can be achieved by forming a small upwardly opening depression or reservoir 158 in the lid 116 (FIG. 18) and/or by forming a similar receptacle indentation (facing the lid; not shown) in the foil closure member itself.

The reservoir, and hence the supply of fragrance, are disposed on the side of the aperture 124 away from the edge of the lid so as to be close to the nostrils of a person drinking from the can. This location is between the aperture 124 and the stay-on heat seal portion 146c and is thus covered by the closure extension 128a when the closure member is sealed on the lid.

A wide variety of concentrated fragrances are readily available and, for the described use, the volume required is about one drop (less than 0.1 ml). Since the fragrance is sealed between the lid 116 and the closure member 128, there is little if any loss of fragrance during storage, owing to the excellent barrier properties of aluminum.

When the foil closure member is peeled back (FIG. 17B) to open the can it exposes the fragrant oil 156, releasing the aroma. As will be apparent from the drawings, the fragrance reservoir 158 is positioned on the can lid in close proximity to the nose of a person drinking straight from the can, to maximize the effectiveness of the aroma.

For use with a lid having a fragrance reservoir, the heat seal 146 securing the closure member 128 to the lid 116 is configured to fully surround the reservoir 158 containing the supply of fragrance. Two specific heat seal designs for this purpose are respectively shown in FIGS. 19 and 20. In FIG. 19, the heat seal area 146a around the aperture 124 is contiguous with the heat seal area 146b surrounding the fragrance reservoir or well 158 and the heat seal portion 146c that secures the "stay on" extension 128a of the closure member to the lid; the design is such that as the lid is peeled back from the aperture, there is a high probability that the fragrance-containing depression 158 in the lid will be partially or fully exposed and the fragrance will start to be released. In FIG. 20, the heat seal area 146d surrounding the fragrance containing reservoir is isolated from the heat seal portions 146a (around the aperture) and 146c (bonding the stay-on closure member extension to the lid), but again, the action of peeling back the closure member results in partial or complete

opening of the reservoir to release the fragrance. In the case of FIG. 20, by isolating the fragrance reservoir 158 from the main heat seal areas 146a and 146c, the probability of premature evaporation of the fragrance owing to heat input from the heat sealing tools is significantly reduced.

In brief summary, the present invention provides a novel can end with a safe and convenient aperture and a heat sealable foil closure, suitable for use with carbonated beverages or similar products. Among the benefits and advantages that may be achieved with the cans of the invention are the following:

-- improved sanitary characteristics, because no external exposed surface is introduced into the beverage, as occurs when present-day scored lids are opened with a riveted pull-tab system;

-- enhanced aesthetics, in that the peelable foil closure can be embossed and printed (inside and/or outside);

-- increased selection of aperture size and shape since, while there will be some limitations, a wider range of aperture sizes and shapes will be possible than is the case with present-day scored lids;

-- greater safety, in particular because the reverse curl of the aperture-defining bead eliminates sharp edges;

-- ease of opening, and concomitant consumer satisfaction, since marketing studies in the food industry indicate that consumers prefer easy-peel closures to the scored ends of present-day carbonated beverage cans as well as to the use of can openers;

-- ease of use, since a can with this end design has better pouring characteristics and may be easier to drink from directly.

Especially preferred embodiments of the invention are carbonated beverage cans with readily peelable closure members characterized by a burst resistance of at least about 620 kPa or higher, e.g. 689 kPa or above, and a shelf life of at least six months or more. The creep resistance and barrier properties of foil closures, together with the shear strength of heat seals, enable attainment of the desired extended shelf life.

By way of further illustration of the invention, reference may be made to the following specific examples, in which Example 1 is a hypothetical example and Examples 2 and 3 describe burst resistance tests performed on actual samples of can lids with heat-sealed closures embodying features of the invention, while Example 4 describes actual tests related to shelf life. In these Examples, identifications of aluminum alloys by four-digit numbers with the prefix "AA" refer to designations of aluminum alloy compositions registered with the Aluminum Association, as will be understood by persons skilled in the art.

EXAMPLE 1

An illustrative can end (lid) embodying the present invention with a heat sealed foil/polymer laminate closure might be constructed with the following specification:

Aperture diameter (A)	:	25.4 mm
Flange angle	:	20-25°
Laminate	:	100 μ foil (AA 3104) + 25 μ polymer (e.g., polyethylene, polypropylene, polyester)
Heat seal width	:	2.5 mm
Can lid sheet	:	228 μ (AA 5182 alloy) with a heat sealable coating

It will be understood that a range of values for each parameter should be possible. The target burst resistance for such a lid would be > 620 kPa and the target peel force (at 90° to the plane of the aperture) would be < 1.8 kg.

EXAMPLE 2

Tests were performed to determine peel strength and burst resistance for can ends (lids) of "202" can end size (a standard can size designation) in accordance with the invention, having an annular frustoconical flange with an 18° angle of slope defining an aperture 19 mm in diameter, covered by a foil closure heat sealed to the flange around the aperture. The lids were formed from can end sheet of AA5182 aluminum alloy at a gauge of 22 μ, and their outer surfaces were coated with "Valspar" unicoat at a coating weight of 1.5 mg/in^2 (approximately 1.5 μ thick). The closures were made from heat sealable stock of 50 μ foil of AA3105 aluminum alloy, coated on its inner surface (the surface in contact with the aperture-defining frustoconical flange) with Rorschach TH388® vinyl heat seal lacquer at a coating weight of 6 g/m^2 (about 6 μ thick). Heat sealing was performed at various selected tool

temperatures (on the side of the foil closure) of from 230° to 280°C, with a pressure of 975 N and a time of 0.3 sec.

Initially, to determine peel strength, T-peel test pieces were prepared from the can end sheet and heat sealable foil stock described above by heat sealing 15 mm wide strips of the foil stock to 15 mm wide can end sheet samples for different heat seal temperatures (as listed in FIG. 10). Results, summarized in FIG. 10, show that the peel strength can be adjusted for this combination of materials by modifying the heat seal temperature. As mentioned above, a peel force of between about 10 N and about 15 N is generally regarded as acceptable for an easy opening container. Since the anticipated width of the heat seal for closures embodying the present invention may be typically or conveniently approximately 15 mm, the peel forces will fall within this acceptable range.

To test burst resistance, a number of formed and heat sealed can ends as described were subjected to a standard burst test in which the rim of the can end is clamped to a rubber gasket seal and a gradually increasing air pressure is applied to the inner lid surface. The deformation of the lid and seal can be observed during the test and the maximum pressure at failure is recorded. After testing the lids are examined to determine the mode of failure.

The results of these burst tests are shown in FIG. 11. For these tests, burst pressures of approximately 414 kPa were recorded. During the tests it was noted that the foil closure 28 stretched and "domed" to a point where the tension in the foil had developed a significant peel component, i.e., the tangent (in a vertical plane) to the bulged foil closure 28 at the

edge of the aperture 24 exceeded the 18° slope angle of the flange 30, as illustrated diagrammatically in FIG. 9. Failure of the seal occurred by a peel initiated at the inner edge of the aperture.

A 414 kPa burst resistance is sufficient for low levels of carbonation or for normally carbonated beverages under standard conditions of use. However, since carbonated products must be capable of tolerating varying degrees of extreme conditions (elevated temperature, agitation, etc.), the normal targeted burst resistance is generally 620 kPa or higher. In the case of the materials employed in this Example, higher burst resistance should be achieved with this gauge of foil if a higher flange angle (e.g. 25°) were to be used.

EXAMPLE 3

A further series of can ends in accordance with the invention were prepared and tested. The lid members were the same (dimensions, gauge, alloy, coating, flange slope angle and aperture diameter) as in EXAMPLE 2, but the closures were made of heat sealable foil stock of 70 μ foil of AA9802 aluminum alloy with an inner surface coated with a vinyl heat seal lacquer of unknown formulation. Heat sealing was performed with a tool temperature (on the foil closure side) of 280°C, under the same pressure and time conditions as in EXAMPLE 2.

These materials (can end sheet and foil closure) were subjected to peel strength testing. Peel strengths of greater than 20 N /15 mm were recorded for these samples. This is too high for convenient peeling and indicates that the vinyl lacquer was not a suitable formulation.

Samples of the lids and closures were formed, subjected to heat sealing, and tested for burst resistance. Burst resistance was found to be > 620 kPa. During the burst tests, the foil closures bulged to form a shallow dome, but the distortion was not sufficient to create a significant peel component to the resultant tension force.

Failure of the lids eventually occurred by distortion of the can end shell metal. The foil and the heat seal survived the test satisfactorily.

With the thicker foil of this Example, the doming which occurs at pressures below 620 kPa (for the 19 mm aperture) was below the level at which a peel component of force would arise.

EXAMPLE 4

The shelf life of cans in accordance with the invention was tested by preparing a can having a lid in accordance with the invention, including an angled flange having an 18° angle of slope and defining a circular aperture 19 mm in diameter. The closure was aluminum foil 100 μ thick, with a vinyl/acrylic lacquer ("TH 388") used for the heat seal, which had a width of 2 mm. The internal pressure of the can was345 kPa. The can was examined weekly for over eight weeks. Throughout this period, there were no detectable changes in bulge height of the foil closure and there was no detectable change in the heat seal joint (i.e., no sliding).

In a further test, another can was prepared, having a lid in accordance with the invention, including an angled flange having an 18° angle of slope and defining a circular aperture 22.2 mm in diameter. The closure was aluminum foil 100 μ thick, with a vinyl/acrylic

lacquer ("TH 388") used for the heat seal, which had a width of 2 mm. The internal pressure of the can was 414 kPa. The can was examined weekly for over six weeks. Throughout this period, there was no change in bulge height of the foil closure and no detectable change in the heat seal joint (i.e., no sliding).

It is to be understood that the invention is not limited to the features and embodiments hereinabove specifically set forth, but may be carried out in other ways without departure from its spirit.

CLAIMS:

1. A can comprising:

(a) a metal can body having an open upper end;

(b) a substantially rigid metal can lid peripherally secured to and closing said can body end, said lid having an upper surface;

(c) a frustoconical annular flange formed in a portion of said lid and projecting upwardly from said lid upper surface, said flange having an upwardly sloping outer surface and an annular inner edge lying substantially in a plane and defining an aperture with an average diameter between about 16 mm and about 25 mm, said flange outer surface being oriented at an angle of slope between about 12.5° and about 30° to said plane; and

(d) a flexible closure member of a material comprising a metal foil, extending entirely over said aperture and peelably bonded by a heat seal to said flange outer surface entirely around said aperture.

2. A can as defined in claim 1, wherein said can has a geometric axis, said lid upper surface is substantially flat, said aperture is circular and said flange is disposed in a portion of said lid eccentric to said geometric axis.

3. A can as defined in claim 1, wherein said closure member and heat seal have a tear/shear force resistance of at least about 4.5 kg/cm, and wherein said average diameter of said aperture and said angle of slope of said flange are mutually selected such that when the closure member is subjected to differential

pressure of a given value between about 345 kPa and about 690 kPa within the can, the tear/shear force exerted on the closure member and heat seal does not exceed said tear/shear force resistance.

4. A can as defined in claim 3, wherein said tear/shear force resistance is between about 4.5 and about 13.4 kg/cm.

5. A can as defined in claim 1, wherein said closure member material is deformable, and wherein said average diameter of said aperture, said angle of slope of said flange, and the deformability of said material are mutually selected such that said closure member, when subjected to differential pressure of not more than about 689.5 kPa, preferably not more than about 620 kPa in the can, bulges upwardly with an arc of curvature such that a line tangent to said arc at said inner edge of said flange lies at an angle to said plane not substantially greater than said angle of slope of the flange outer surface.

6. A can as defined in claim 1, wherein said closure member and heat seal have a tear/shear force resistance of at least about 13.4 kg/cm, and wherein said average diameter of said aperture and said angle of slope of said flange are mutually selected such that when the closure member is subjected to differential pressure of not more than about 689.5 kPa, preferably not more than 620 kPa, within the can, the tear/shear force exerted on the closure member and heat seal does not exceed said tear/shear force resistance.

7. A can as defined in claim 5, wherein said closure member and heat seal have a tear/shear force

resistance of at least about 13.4 kg/cm, and wherein said average diameter of said aperture and said angle of slope of said flange are mutually selected such that when the closure member is subjected to differential pressure of not more than about 689.5 kPa, preferably not more than about 620 kPa within the can, the tear/shear force exerted on the closure member and heat seal does not exceed said tear/shear force resistance.

8. A can as defined in any one of claims 1-7, wherein said heat seal has a 90° peel strength between about 8 N and about 20 N.

9. A can as defined in any one of claims 1-8, wherein said annular inner edge is formed with a reverse bead curl.

10. A can as defined in claim 9, wherein said reverse bead curl is substantially tangent to the upwardly sloping outer surface of the flange.

11. A can as defined in any one of claims 1-10, wherein said metal foil is aluminum alloy foil.

12. A can as defined in claim 14, wherein said aluminum alloy foil has a thickness between about 75 μ and about 100 μ.

13. A can as defined in claim 1, wherein said heat seal is formed as an annulus surrounding said aperture and having a width between about 2 mm and about 3 mm.

14. A can as defined in any one of claims 1-13, wherein said closure has a tab portion with a manually graspable free end and an extension overlying said lid in opposed relation to said tab portion, said heat seal

including an annulus surrounding said aperture and a further seal portion bonding said extension to said lid such that the peel force required to separate the extension from the lid is greater than that required to separate the closure member from the lid at the annulus, whereby the aperture can be opened by peeling back the closure member while the closure member remains secured to the lid by said further seal portion.

15. A can as defined in claim 14, including a body of fragrance-providing material disposed between the closure member and the lid and surrounded by the heat seal such that when the closure member is subjected to a peel force effective to open the aperture, the body of fragrance-providing material becomes exposed.

16. A can as defined in any one of claims 1-15, wherein said body is a drawn and ironed metal can body for holding a carbonated beverage; wherein the lid is formed with a peripheral rim engaging the open upper end of the can body and projecting upwardly above the upper surface of the lid; wherein the body is formed with an outwardly concave lower end, the rim and body lower end being mutually shaped and dimensioned to permit stable vertical stacking of the can with other identically shaped and dimensioned cans; wherein the flexible closure member is domed so as to rise to a height above the annular flange; and wherein the height of the rim, the concavity of the body lower end, and the height to which the closure rises above the annular flange are such that there is sufficient clearance between the lid upper surface of the can and the concave bottom of another identical can stacked above it to accommodate the domed closure.

17. A can as defined in any one of claims 1-16, containing a carbonated beverage.

18. A can lid member mountable on a metal can body having an open upper end so as to be peripherally secured to and to close said can body end, said lid comprising a substantially rigid unitary metal member having an upper surface with a frustoconical annular flange formed in a portion of said lid and projecting upwardly from said lid upper surface, said flange having an upwardly sloping outer surface and an annular inner edge lying substantially in a plane and defining an aperture with an average diameter between about 16 mm and about25 mm, said flange outer surface being oriented at an angle of slope between about 12.5° and about 30° to said plane, said flange being arranged and configured to be closed by a flexible closure member extending entirely over said aperture and peelably bonded to said flange outer surface around said aperture.

19. A method of producing a can containing a carbonated beverage, comprising:

(a) filling a drawn and ironed metal can body, having an open upper end, with a carbonated beverage, and

(b) closing said open upper end of said can body by peripherally securing a substantially rigid metal can lid to said can body end, said lid having an upper surface and a frustoconical annular flange formed in said lid and projecting upwardly from said lid upper surface, said flange having an upwardly sloping outer surface and an annular inner edge lying substantially in a plane and defining an aperture with an average diameter

between about 16 mm and about 25 mm, said flange outer surface being oriented at an angle of slope between about 12.5° and about 30° to said plane, and a flexible metal foil closure member extending entirely over said aperture and peelably bonded by a heat seal to said flange outer surface entirely around said aperture.

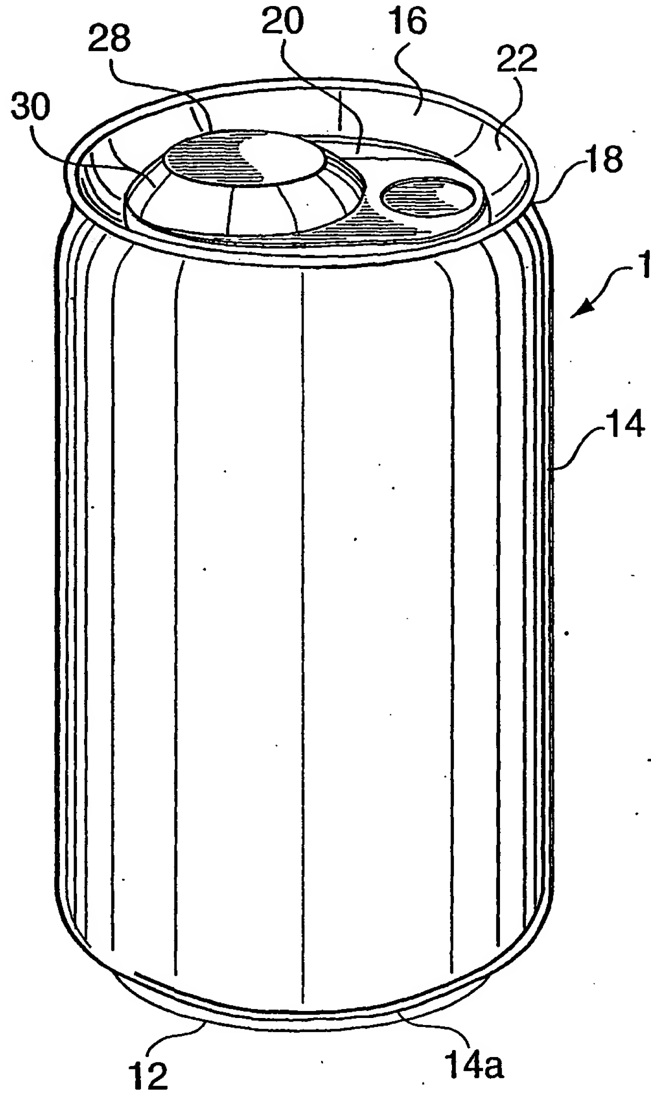

FIG. 1

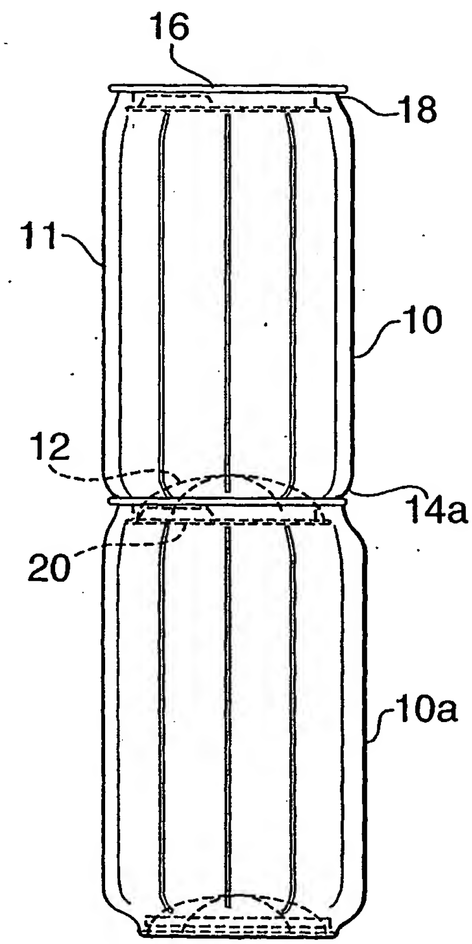

FIG. 8

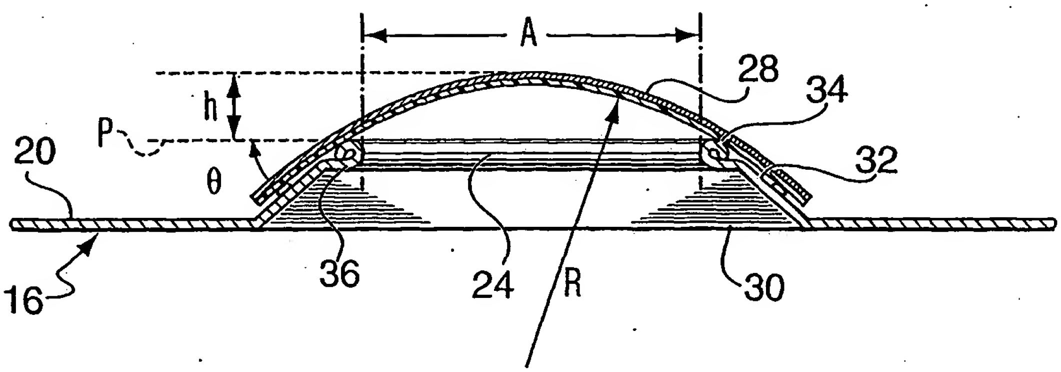

FIG. 2A

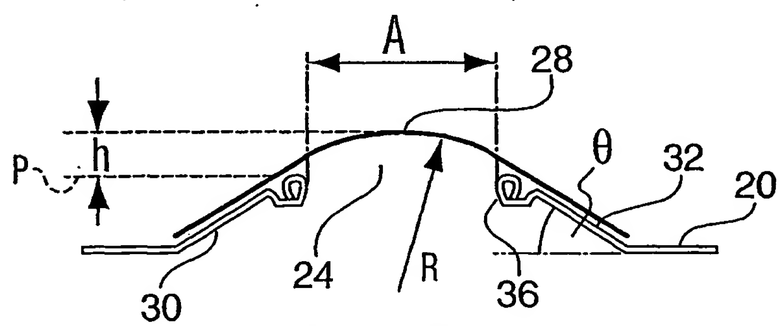

FIG. 2B

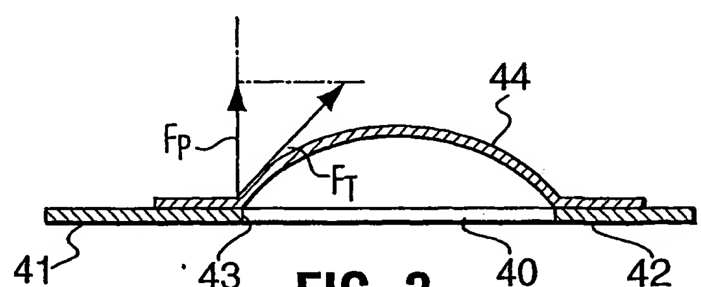

FIG. 3

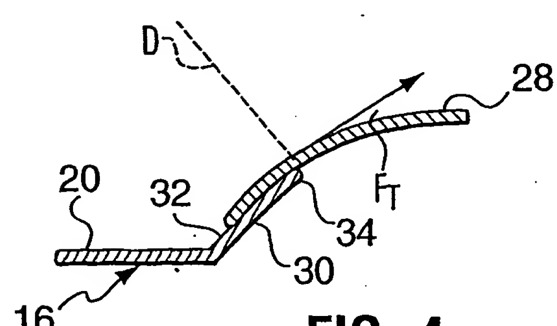

FIG. 4

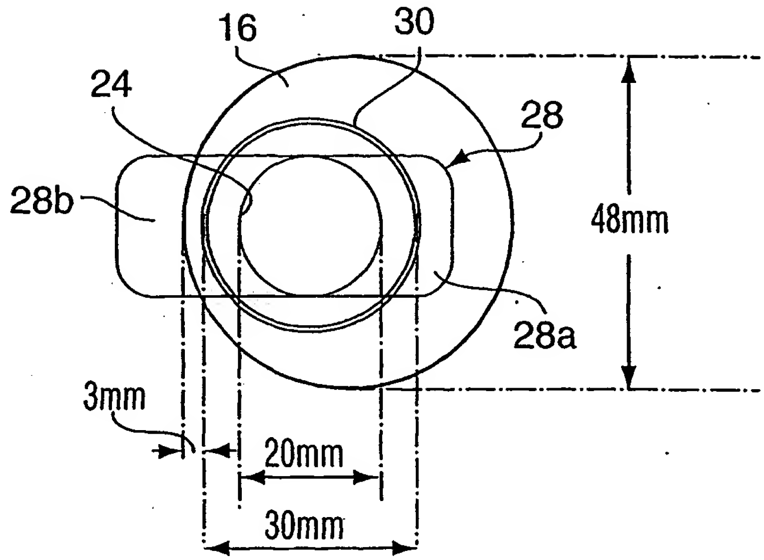

FIG. 5

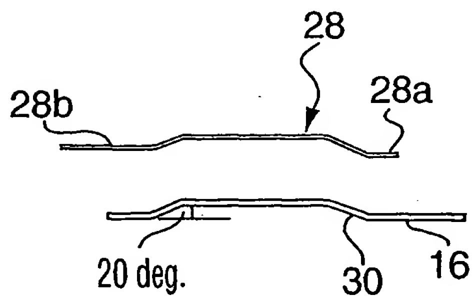

FIG. 6

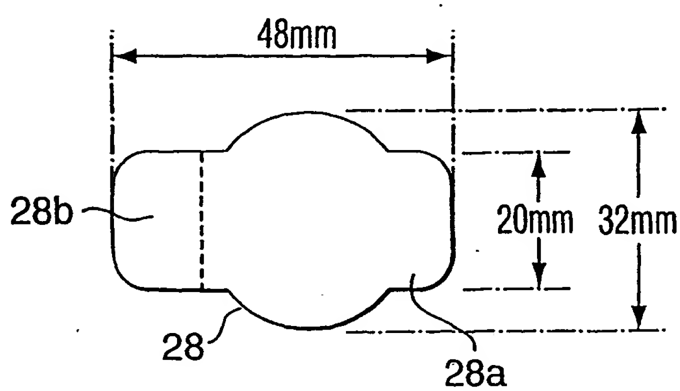

FIG. 7

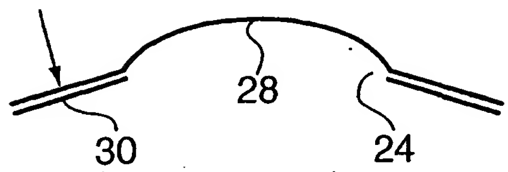

FIG. 9

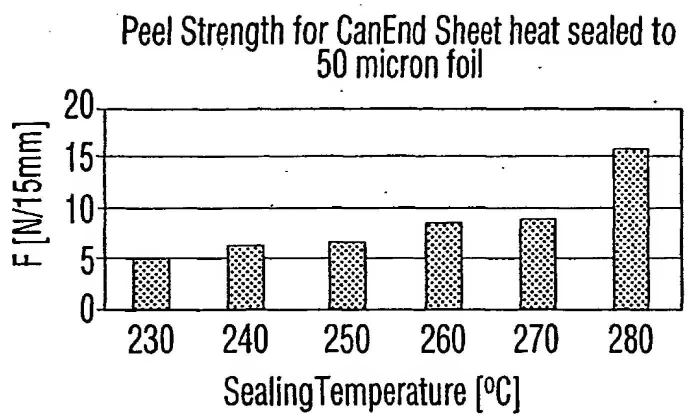

FIG. 10

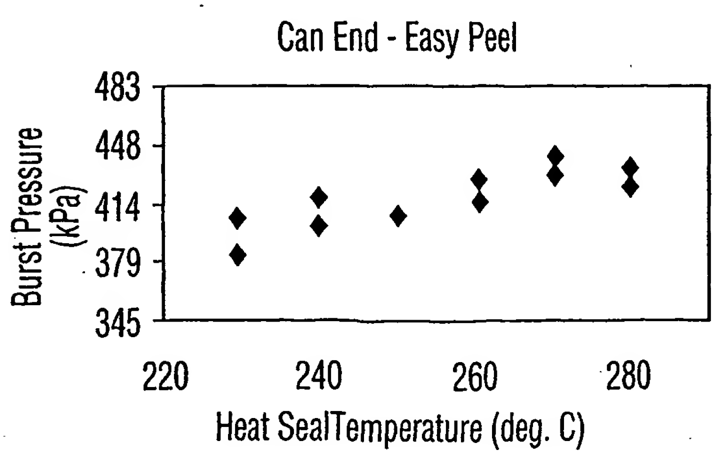

FIG. 11

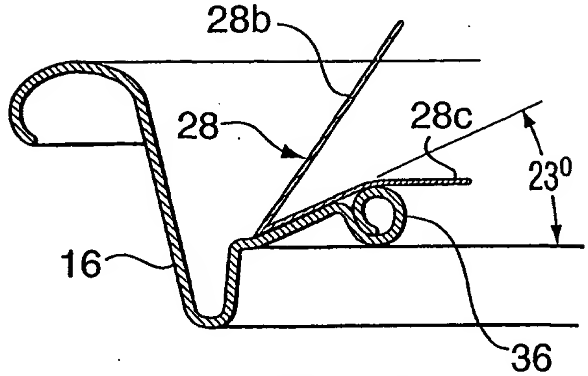

FIG. 12

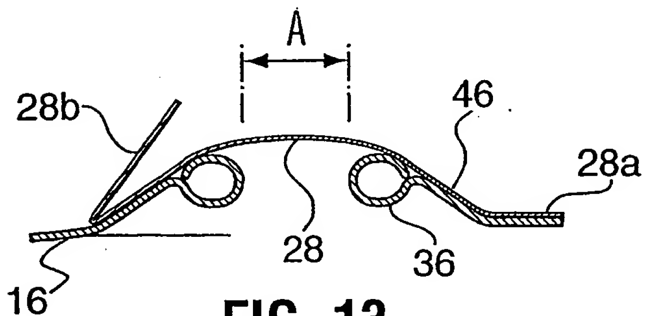

FIG. 13

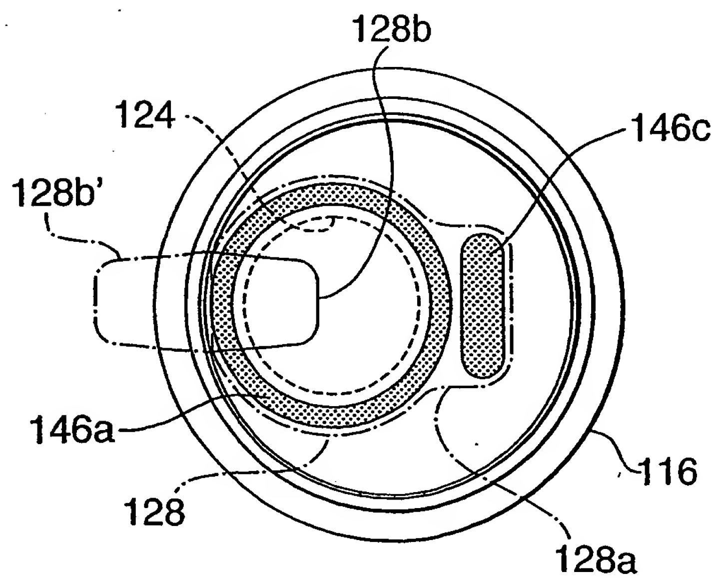

FIG. 15

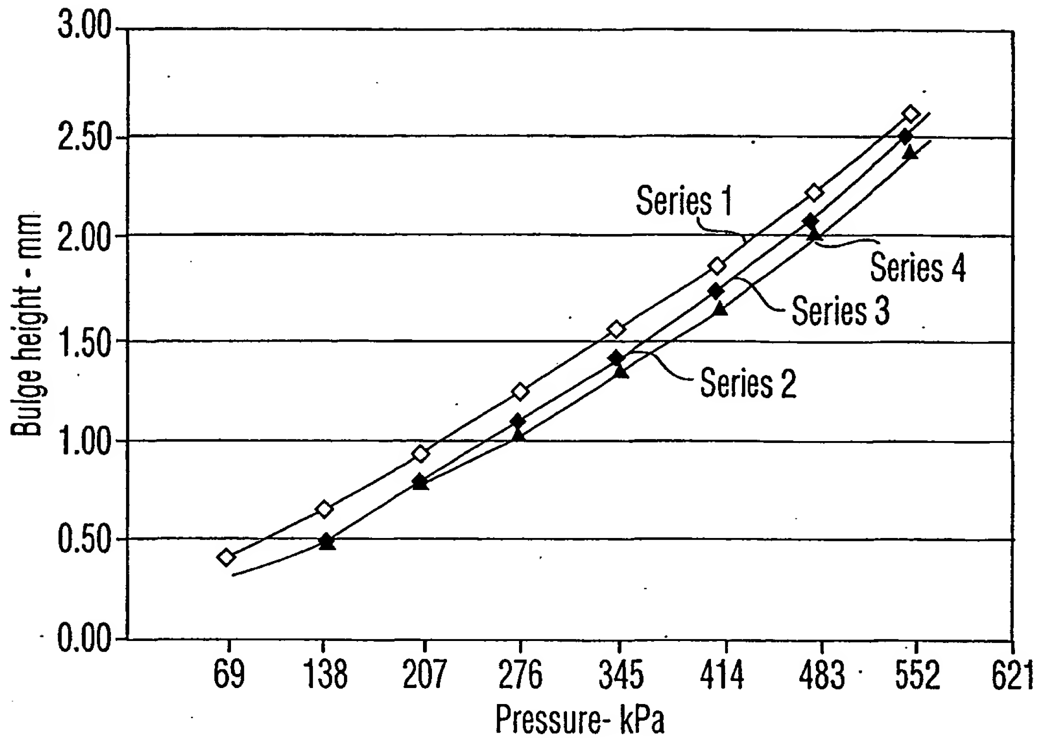
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Bulge height - mm
Series 1
Series 4
Series 3
Series 2
69
138
207
276
345
414
483
552
621
Pressure- kPa

FIG. 14

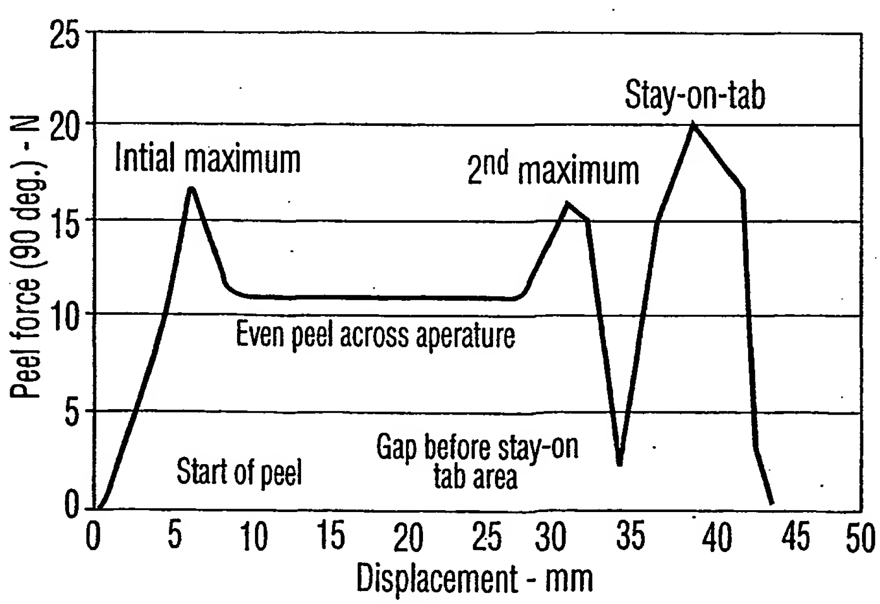
25
20
15
10
5
0
Peel force (90 deg.) - N
Stay-on-tab
Intial maximum
2nd maximum
Even peel across aperature
Gap before stay-on
tab area
Start of peel
0
5
10
15
20
25
30
35
40
45
50
Displacement - mm

FIG. 16

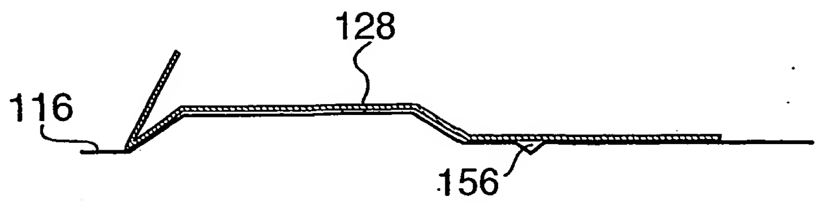

FIG. 17A

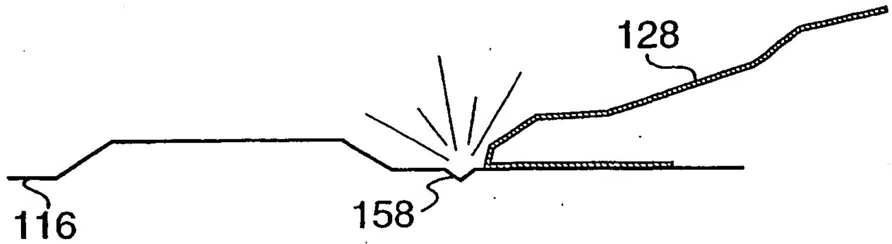

FIG. 17B

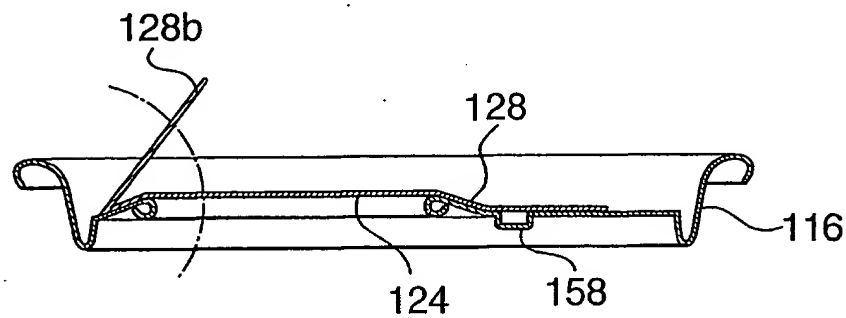

FIG. 18

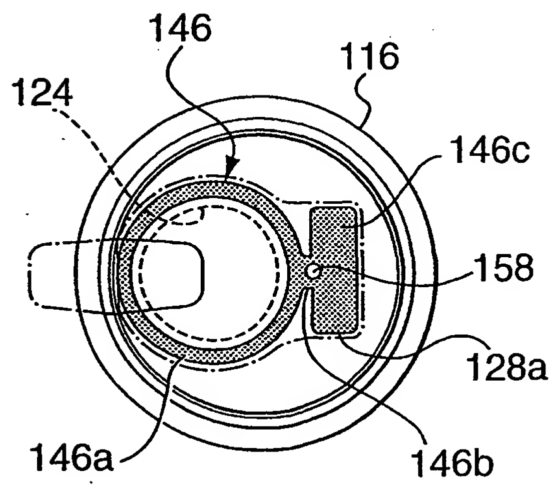

FIG. 19

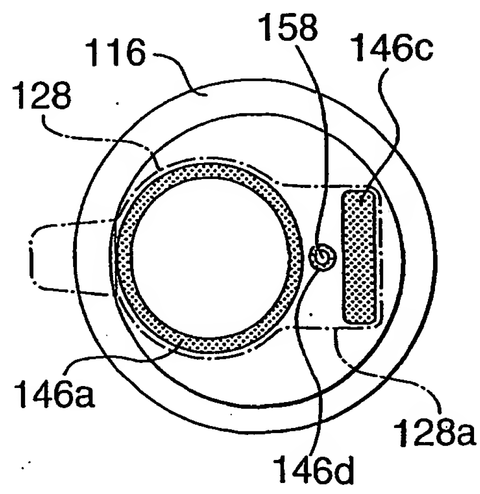

FIG. 20

INTERNATIONAL SEARCH REPORT

Inter ...plication No
PCT/CA 01/00954

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B65D17/50

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3 889 844 A (VIKER HARRIS W ET AL) 17 June 1975 (1975-06-17) cited in the application column 3, line 4 -column 5, line 40; figures 1,2	1,2,13, 14,18,19
Y	US 4 680 917 A (HAMBLETON THOMAS P ET AL) 21 July 1987 (1987-07-21) column 7, line 15 -column 8, line 52; figures 1-3	1,2,13, 14,18,19
A	DE 82 28 681 U (BLECHWARENFABRIKEN ZÜCHNER GMBH & CO) 6 October 1983 (1983-10-06) page 6, line 25 -page 8, line 13; figure 2	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 October 2001	17/10/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Olsson, B

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/CA 01/00954

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 3889844	A	17-06-1975	AU	472220	B	20-05-1976
			AU	7277674	A	11-03-1976
			DE	2441490	A1	20-03-1975
			DK	444174	A	28-04-1975
			FR	2242302	A1	28-03-1975
			GB	1477862	A	29-06-1977
			JP	50050184	A	06-05-1975
			NL	7411089	A	04-03-1975
			US	3964415	A	22-06-1976
US 4680917	A	21-07-1987	US	4557398	A	10-12-1985
			CA	1230564	A1	22-12-1987
			EP	0171498	A2	19-02-1986
			JP	61060448	A	28-03-1986
DE 8228681	U	06-10-1983	DE	8228681	U1	06-10-1983